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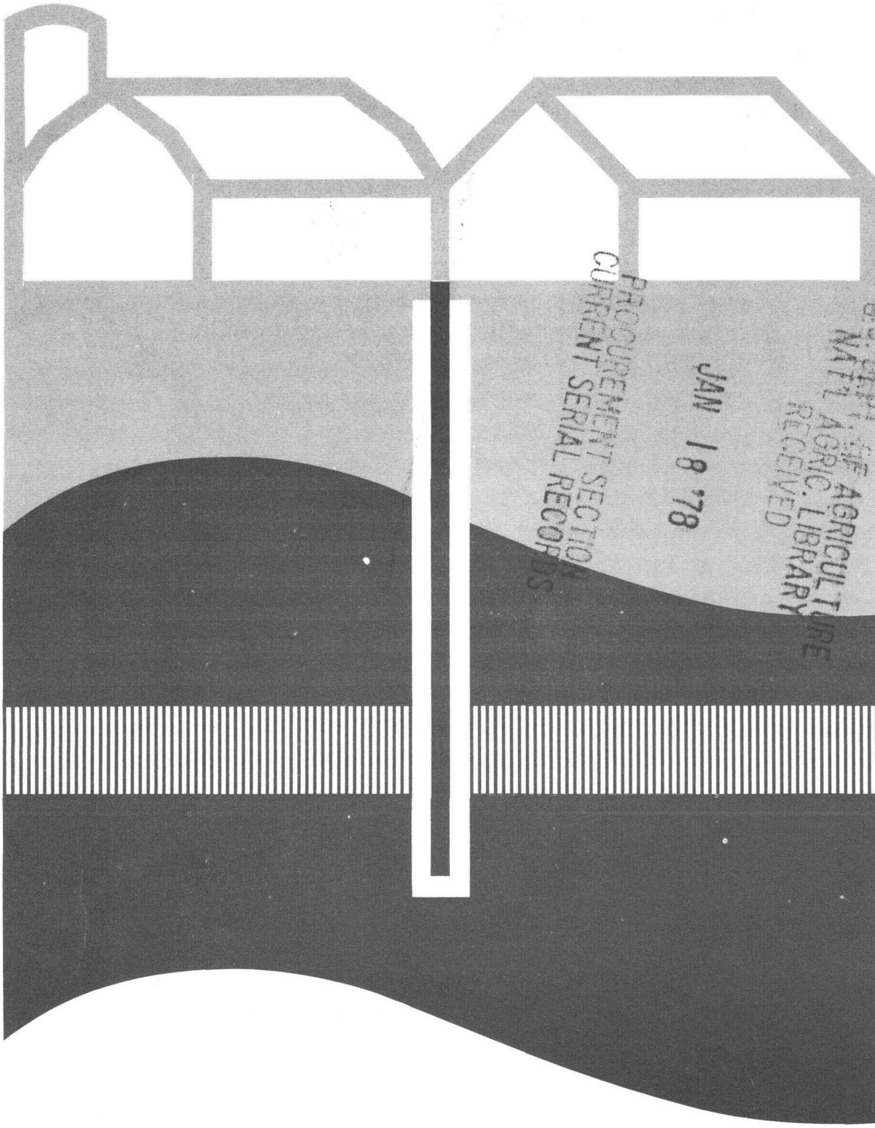
Water Supply Sources for the Farmstead and Rural Home



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CONTENTS

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WATER-SUPPLY SOURCES for the Farmstead and Rural Home

Water-supply systems for farmsteads and rural homes may be developed from either ground water or surface water sources. Ground water sources are wells and springs. Surface water sources include streams, lakes, ponds, and cisterns.

A properly located and constructed well is the preferred source of water for domestic use. Well water is less likely to be contaminated than water from other sources. It is, however, apt to contain more dissolved minerals such as iron and manganese.

Surface water sources should be used only as a last resort because of the cost and difficulty of making the water safe to drink. However, surface water may be suitable for irrigating, firefighting, livestock, and other nondomestic purposes.

WATER REQUIREMENTS

Quality

Water for domestic use should be safe and pleasant to use.

Water may be unsafe because of its bacterial or toxic-chemical content. Contaminated water often carries disease-producing organisms or parasites. Surface water is almost always contaminated; well and spring water can become contaminated. Contaminated water can generally be made safe to drink by proper treatment.

Water may be unpleasant or unsatisfactory for use because of its chemical or physical quality. For example, excessive amounts of calcium and magnesium salts in water make it "hard." Hard water is less desirable for bathing, cooking, and laundering than soft water.

Suspended silt in water makes it look muddy or cloudy. Excessive amounts of dissolved minerals, gases, or decaying organic matter may give it a bad taste and odor.

CAUTION

A water's appearance and taste can be misleading. Many illnesses and deaths have resulted from drinking clean-looking, pleasant-tasting water from an unsafe source.

SPECIFIC INFORMATION

The occurrence of water and other conditions can vary widely from one place to another. Also, regulations and standards for developing a water-supply system may differ from one jurisdiction to the next. For these reasons, you will need to supplement the information in this bulletin with specific information about your particular area.

Local authorities are the best source of specific information. Talk with health officers, your county agricultural agent, Soil Conservation Service people, well drillers, and others. Here summarized are points to check on and questions to ask. Some are discussed in the text.

- What are the possible sources of a water supply? Which might be the best and perhaps the most economical?
- What are the laws regarding surface and subsurface water rights? They may vary in the different States.
- What quality requirements must be met in order to provide a safe and economical water supply?
- What tests of the water are required or recommended? Who makes these tests? Who evaluates the results?

Have your water tested for bacterial content and approved before using it. Tests for chemical and physical quality may also be desirable in many areas. Your local health officer can tell you what tests are necessary or recommended and where you can have them done. He can also evaluate the results.

Never use water for domestic purposes unless it has been approved.

Your water may test unsafe or otherwise unsatisfactory. Effective economical treatment is not always possible. You may have to consider alternative water sources.

Quantity

How much water will you and your family need? How much will you need for your farm? This table can help you determine your daily water requirements:

Needed by—	*Gallons per day*
Each person	30–70
Each milk cow	[1] 35
Each horse, dry cow, or beef animal	6–12
100 chickens	3–7
100 turkeys	7–18
Each hog	2–4
Each sheep	2

[1] Includes both drinking water and sanitation requirements.

Lawn and garden watering are often important water uses. For 1 inch of water on 1,000 square feet of lawn or garden, about 700 gallons of water are required. This amount allows for some loss by evaporation or other causes.

Your water source should produce at least your minimum daily water requirements. If the source is a low-yielding well or spring, you may need a storage tank or cistern to supply water during periods of peak use.

GROUND WATER SOURCES

"Ground water" may be defined as the water in the ground that will move or drain freely by gravity. It is the water in the zone of saturation—the zone beneath the surface of the ground in which all voids or openings in the rock and soil are filled with water (fig. 1).

The upper limit of the zone of saturation is called the water table or ground-water level. The water table is not flat—it follows the general contour of the earth's surface. It is higher under hills than beneath valleys. It may be near the surface or many feet below it. It may rise during rainy spells and drop during dry periods.

Water is sometimes confined above the main zone of saturation by impervious stratum. It is then called perched water, and its upper limit is called a perched water table.

Ground water moves slowly but constantly toward points of lower elevation and may surface in springs, lakes, streams, rivers, or the oceans. It is replenished by precipitation (rain, snow, sleet, or hail) or irrigation that percolates down through the earth.

The stratum in the earth where the water occurs is called an aquifer. Wells are sunk down into an aquifer. An aquifer may cover hundreds of square miles. Water may travel a long way before it reaches your well or spring.

An aquifer may be "sandwiched" between two impervious strata. The ground water is then likely to be under pressure in some places. It will rise in a well sunk through the dense upper stratum into the aquifer. This would be an artesian well.

Wells

Proper location and construction of a well are extremely important. Numerous outbreaks of water borne diseases have been directly attributed to faulty well construction

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HYDROLOGIC CYCLE

There is a continuous exchange or circulation of water between the earth and the atmosphere. This is called the hydrologic cycle and is illustrated in figure 1.

Water evaporates into the atmosphere from the oceans, and winds carry the moisture-laden air over the land. Water also evaporates from the ground, from vegetation, and from lakes, rivers, and other bodies of water.

The water falls as precipitation—rain, snow, sleet, and hail. Part runs over the surface of the ground and returns via streams and rivers to the oceans. Part is utilized by the vegetation and returned to the atmosphere by transpiration. Part percolates down through the porous formations of the earth, becomes ground water, and eventually reaches the sea.

Ground water is the source of water for wells and springs—the recommended sources of water for rural domestic use.

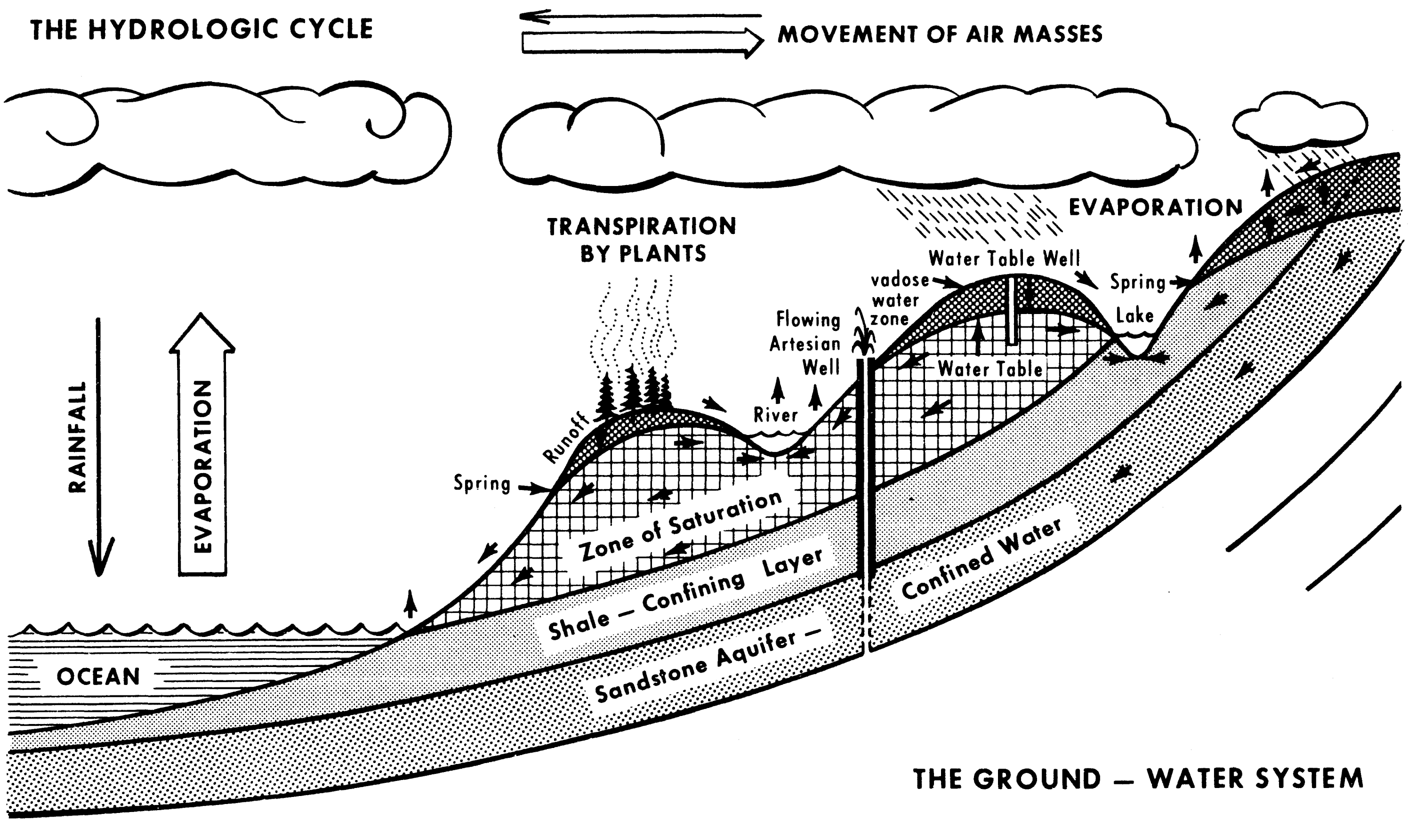

FIGURE 1.— The hydrologic cycle illustrates how water occurs in nature. Water within the zone of saturation is ground water—the source of water for wells and springs.

that permitted the entrance of contaminated water.

Wells may be dug, bored, drilled, driven, or jetted. All but drilled wells are limited to loose, unconsolidated formations containing few large rocks.

Considerations in choosing the type of well include: Ground formation, desired yield, depth to the water table, characteristics of the aquifer, and construction costs.

Drilled wells are usually constructed by well-drilling contractors because of the special equipment and skill required. Many jurisdictions require that all types of wells be constructed by licensed well drillers. Even where not required, construction by a well driller is recommended. Good workmanship and proven experience are important in well construction.

Don't choose a well driller on the basis of price alone. One driller may quote a higher price than another, but he may also provide a better well. For example, he may drill deeper for better-quality water. Or, he may do a better job of sealing the well against contamination. Or, he may use a better grade of casing. A safe, adequate water supply is most important.

If you have a particular well driller in mind, check his work with your local health officer or with neighbors for whom he has recently constructed a well. For mutual protection, some sort of written agreement with the well driller is recommended. It should cover general construction specifications, costs, and payment arrangements.

CAUTION

There is no known safe distance at which a water well may be located from an uncased waste-disposal well.

Disposal of waste into ground water should never be permitted unless extreme precautions are taken to prevent the contamination of wells. The cost of the required investigation and construction to insure noncontamination makes it impractical to use waste-disposal wells on farms with water wells.

Location

Locate a well above and as far as reasonably possible from known or possible sources of contamination. Minimum recommended distance are:

Source of contamination	*Minimum distance (feet)*
Waste disposal lagoons	300
Cesspools	150
Livestock and poultry yards	100
Privies, manure piles	100
Silo pits, seepage pits	150
Milkhouse drain outlets	100
Septic tanks and disposal fields	100
Gravity sewer or drain not pressure tight	50
Pressure-tight gravity sewer or drain	25

Wells should be located for ease of maintenance and service. No permanent structure that would interfere with servicing should be built over a well. When located adjacent to a building, the well should be at least 2 feet beyond the drip line of the eave. Overhead utility lines should not interfere with erection of the well driller's boom.

Construction

Construction characteristics of the different types of wells are given in table 1.[1] Table 2 gives the recommended minimum standards of construction. Local regulations or conditions may call for or warrant some deviation from these standards.

Dug Wells

Dug wells may be constructed with either hand tools or powered tools (fig. 2). They are usually 3 to 4 feet in diameter but may be much larger. While usually less than 50 feet deep, they must sufficiently penetrate the water table. Dug wells may fail during dry periods.

In formations of sand mixed with clay and silt, large-diameter dug wells offer an advantage over other types of wells. Water moves slowly through such formations and the larger storage area is desirable.

With careful construction, dug wells can be cased as tightly as other types of wells. Frequently used for casing are concrete well rings, 3 feet in diameter and 2 feet in length. The well hole is made 12 inches larger in diameter than the well ring, and the upper part of the annual space is filled with concrete (see table 2). A gravel pack may be installed outside the rings below the pumping water level.

Dewatering of a dug well while digging below the water line requires considerable skill and experience.

Bored Wells

Bored wells are much like dug wells, but they may be deeper and are usually smaller in diameter (fig. 3). They are constructed with either hand augers or powered augers.

Hand-bored wells are usually 8 inches or less in diameter; power-bored wells may be as large as 3 feet in diameter.

Bored wells are usually cased their entire length. Some may require a screen for proper entrance of water.

Construction principles of bored wells are simple. However, skill and experience are required for best results. Collapse of the hole with loss of the boring equipment is possible.

Driven Wells

A driven well consists of coupled pipe sections with a well point and screen on the end (fig. 4). The point is driven down into the ground until the screen is below the water table level. Water enters the well through the screen.

In areas with relatively coarse sand, driven wells can be an excellent and very cheap means of obtaining water. Local dealers can advise on installation in these areas.

[1] Table 1 was adapted from one in Public Health Service Publication No. 24, "Manual of Individual Water Supply Systems" (Revised 1962). Table 2 was adapted from one in the Public Health Service publication, "Recommended State Legislation and Regulations . . . Water Well Construction and Pump Installation Act and Regulations . . .", July 1965.

TABLE 1.—*Practical depths, usual diameters, and suitable geologic formations for the different types of wells*

Type of well	Depth	Diameter	Geologic formation
Dug	0 to 50 feet	3 to 20 feet	*Suitable:* Clay, silt, sand, gravel, cemented gravel, boulders, soft sandstone, and soft, fractured limestone. *Unsuitable:* Dense igneous rock.
Bored	0 to 100 feet.	2 to 30 inches.	*Suitable:* Clay, silt, sand, gravel, boulders less than well diameter, soft sandstone, and soft, fractured limestone. *Unsuitable:* Dense igneous rock.
Driven	0 to 50 feet	1¼ to 2 inches.	*Suitable:* Clay, silt, sand, fine gravel, and sandstone in thin layers. *Unsuitable:* Cemented gravel, boulders, limestone, and dense igneous rock.
Drilled:			
Cable tool	0 to 1,000 feet.	4 to 18 inches.	*Suitable:* Clay, silt, sand, gravel, cemented gravel, boulders (in firm bedding), sandstone, limestone, and dense igneous rock.
Rotary	0 to 1,000 feet.	4 to 24 inches.	*Suitable:* Clay, silt, sand, gravel, cemented gravel, boulders (difficult), sandstone, limestone, and dense igneous rock.
Jetted	0 to 100 feet.	4 to 12 inches.	*Suitable:* Clay, silt, sand, ¼-inch pea gravel. *Unsuitable:* Cemented gravel, boulders, sandstone, limestone and dense igneous rock.

Drilled Wells

Drilled wells are constructed with special well-drilling equipment. Some of the equipment can drill to great depths through rock formations.

Two types of drilling equipment or methods are used—percussion (cable tool) and rotary (conventional and reverse-rotary methods). Geology of the site; desired well diameter, quantity, and depth; and other factors determine which to use.

Drilled wells for household water supply are usually about 6 inches in diameter.

TABLE 2.—*Recommended standards for construction of wells in*

Water-bearing formation and overburden	Oversized drillhole for grout		Well diameter
	Diameter	Depth	Cased portion
Sand or gravel with an overburden of—			
Unconsolidated caving material—sand or sand and gravel.	None required.	None-------	2 in. minimum; 5 in. or more preferred.
Clay, hardpan, shale, or similar material to a depth of more than 20 feet.	Casing size plus 4 in.	Minimum 20 ft.	-----do------
Clay, hardpan, shale, or similar material containing layers of sand or gravel within 15 feet of ground surface.	-----do------	-----do------	-----do------
Creviced or fractured rock such as limestone, basalt lava, granite or quartzite.	-----do------	Through rock formation.	4 in. minimum.
Creviced, shattered, or otherwise fractured limestone, basalt lava, granite, quartzite, or similar rock with an overburden of—			
Unconsolidated caving material, chiefly sand or sand and gravel to a depth of 40 feet or more and extending at least 2,000 feet in all directions from the well site.	None required.	None-------	6 in. minimum.
Clay, hardpan, shale, or similar material to a depth of 40 feet or more and extending at least 2,000 feet in all directions.	Casing size plus 4 in.	Minimum 20 ft.	-----do------
Unconsolidated materials to a depth of less than 40 feet and extending at least 2,000 feet in all directions.	-----do------	Minimum 40 ft.	-----do------
Sandstone with an overburden of—			
Any material except creviced rock to a depth of 25 feet or more.	-----do------	15 ft. into firm sandstone or to 30 ft. whichever is greater.	4 in. minimum.
Mixed deposits, mainly sand and gravel, to a depth of 25 feet or more.	None required.	None-------	-----do------
Clay, hardpan, or shale to a depth of 25 feet or more.	Casing size plus 4 in.	Minimum 20 ft.	-----do------
Creviced rock at variable depth---	-----do------	15 ft. or more into firm sandstone.	6 in. minmum.

Well diameter—Con.: Uncased portion	Minimum casing length or depth	Liner diameter (if required)	Miscellaneous requirements
Does not apply.	20 ft. minimum but 5 ft. below pumping level.	2 in. minimum.	Well screen may be needed for sand-free water; minimum diameter 2 in.
---do------	5 ft. below pumping level.	--do-------	Well screen may be required. Fill annular space around casing with cement grout.
---do------	-----do--------	--do-------	Same as above.
---do------	5 ft. below overburden of rock.	--do-------	Do.
6 in. preferred.	Through caving overburden.	4 in. minimum.	Seat casing firmly in rock.
---do------	Through overburden.	--do-------	Seat casing firmly in rock. Fill annular space around casing with grout.
---do------	40 ft. minimum.	--do-------	Same as above.
4 in. preferred.	Same as oversized drill-hole or greater.	2 in. minimum.	Seat casing firmly in sandstone. Fill annular space around casing with grout. Well screen may be required for sand-free water.
---do------	Through overburden into firm sandstone.	--do-------	Seat casing firmly in sandstone. Well screen may be required.
---do------	Through overburden into sandstone.	--do-------	Same as above. Fill annular space around casing with cement grout.
6 in. preferred.	15 ft. into firm sandstone.	4 in. minimum.	Fill annular space around casing with cement grout. Well screen may be required.

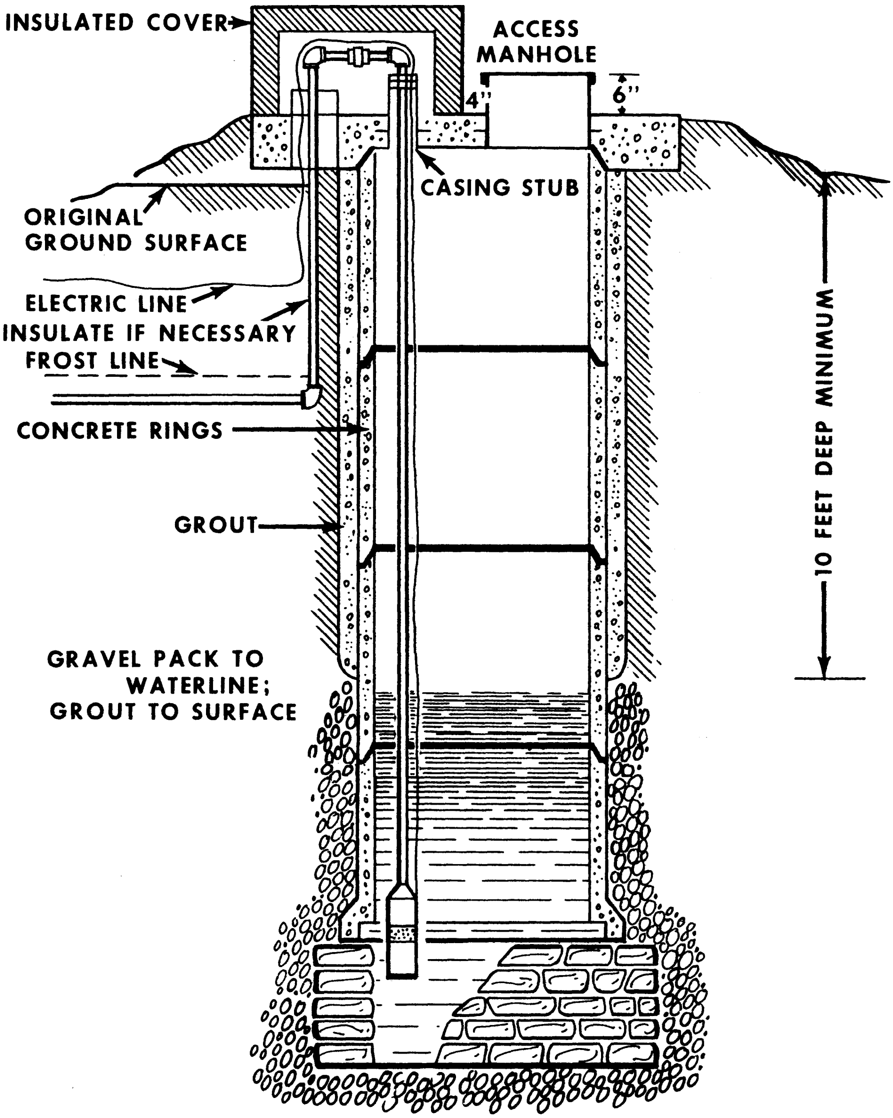

FIGURE 2.—In good, permeable sand or gravel formations, dug wells can yield an ample supply of water. This well is lined with concrete rings. The protective layer of concrete extends down 10 feet to insure watertightness of the upper walls.

Jetted Wells

Jetting or hydraulic well drilling is most successful in sandy soils. It is difficult in clay and hardpan formations and may be impossible in rock formations.

Jetting techniques and equipment used may vary depending on the soil formation, but the basic principle is the same. The hole is made by the force of a high velocity stream of water. The water loosens the mate-

rial and washes the finer particles upward and out of the hole. A jetting tool—bit or point—is pushed down through the loose material.

Protection from Contamination

Wells must be protected from surface contamination. Critical points are where the well passes through the zone of surface contamination, the upper casing terminal, and where the well discharge line connects to the water supply system.

In soils having the permeability of fine sand, bacterial contamination from the surface may extend 20 feet down. In other formations, it may extend even deeper.

When a well is constructed, an opening is made down through the so-called zone of contamination to ground-water. To prevent con-

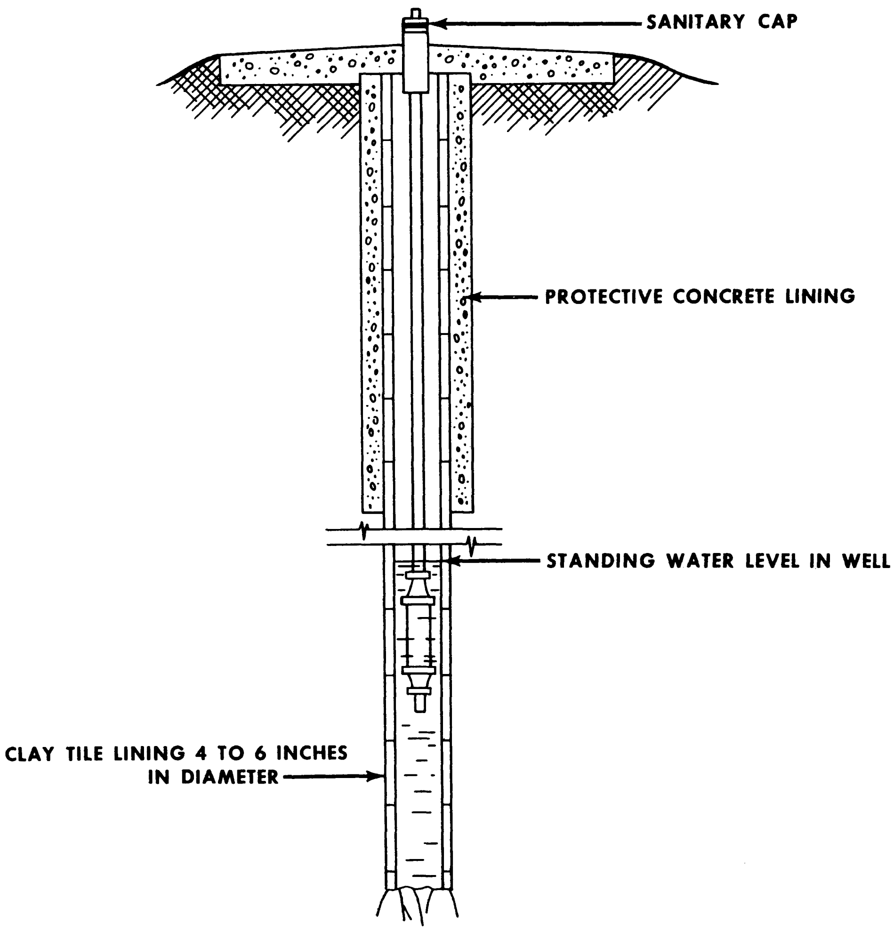

FIGURE 3.—Bored wells are similar to dug wells but are usually deeper and smaller in diameter.

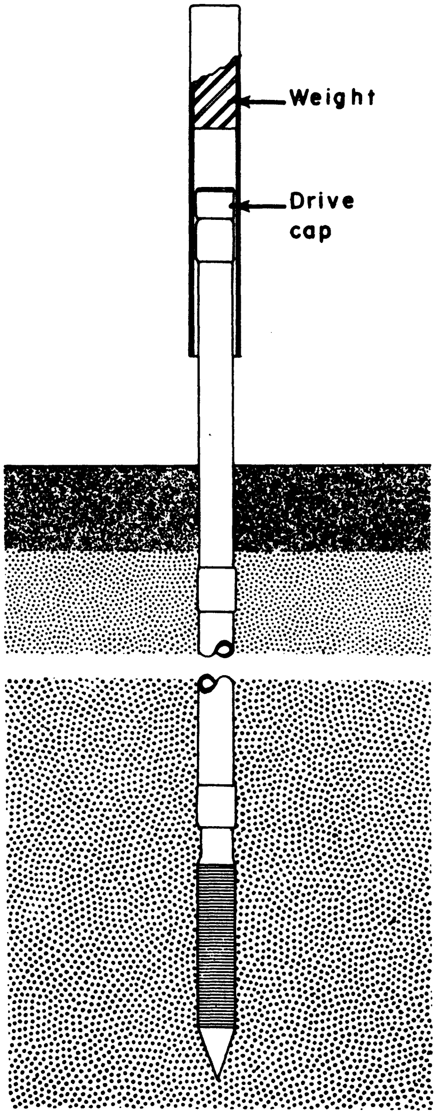

FIGURE 4.—Driven wells may be the quickest and cheapest way to get water in coarse-sand formations. (Reprinted by permission from "Ground Water and Wells."©)

tamination, the well casing must be durable and watertight, and the space between the well casing and the sides of the well hole should be sealed with a watertight cement grout to below the zone of contamination so that water cannot drain around the casing (see table 2 and figure 5).

In fractured- and creviced-rock formations, surface water may drain down relatively fast with little filtering, and the zone of surface contamination may be very deep. In some cases, local geological conditions may make it desirable to case and grout the well to below the pump intake setting.

The upper casing terminal should be provided with a watertight seal or cap. The terminal or the well vent-line should be at least 2 feet above the flood level. For maximum protection, enclose the top of the casing in a pumphouse.

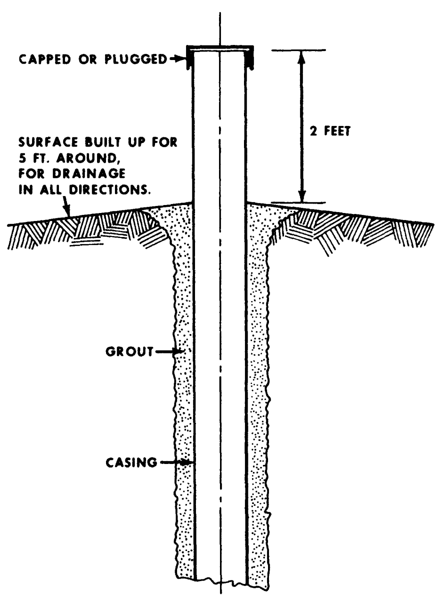

FIGURE 5.—A well as completed by a well driller. Minimum depths for the casing and grout are specified in table 2.

In some areas, it is common practice to terminate the casing below the frost level in a pit. This protects the water-carrying parts from freezing and facilitates the connection of underground discharge piping. However, the U.S. Public Health Service recommends that pits not be used because of the difficulty of providing proper drainage from them. Many cases of well contamination have been traced to the flooding of well pits.

Pitless adapter units, which are installed as a permanent extension of the casing, allow termination of the casing above ground and connection of the discharge piping below ground (fig. 6). Where a well cannot be terminated above the flood level, a pitless adapter unit with a pressure-tight cap should be used.

Well "Development"

Wells in unconsolidated materials usually need to be "developed" for maximum yield of water with minimum drawdown.

Well development consists of removing the finer particles from the water-bearing material around the well screen. This increases the permeability of the material, facilitating the flow of water into the well. It also retards the clogging of screens and pumps by clay and silt material.

The most common method of developing a well is by surging the water. A piston or plunger is moved up and down in the water. This causes the water to surge in and out through the well screen. The fine particles are drawn into the well and then pumped or bailed out of it.

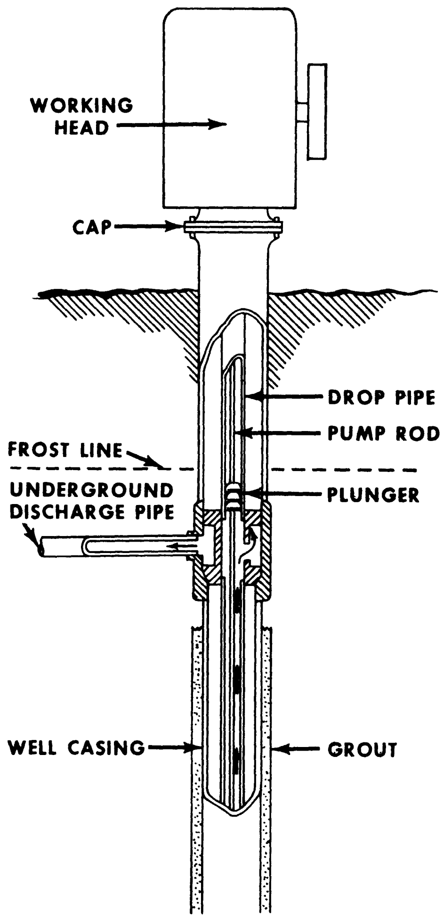

FIGURE 6.—Pitless adapter units allow termination of the well casing above ground and connection of the discharge piping under ground.

Well Disinfection

Before water from a new well is analyzed for purity, the entire water-supply system should be disinfected to kill any bacteria introduced during construction of the well or installation of the plumbing. Disinfection is usually written into the well-drilling contract.

Disinfect the well in the evening because the water cannot be used for 8 to 12 hours thereafter. Follow these steps:

1. Open the well (remove the cap or sanitary seal) and pour 1 gallon of chlorine bleach into it. Calcium hypochlorite tablets might also be used.

2. Connect a garden hose to the nearest hose bib, and draw water through it until there is a strong odor of chlorine.

3. Flush the inside of the well casing or the interior walls of a dug well thoroughly with the chlorinated water. Also wash the well cap or well seal.

4. Draw water through each faucet and other water outlet inside and outside the house until there is a strong odor of chlorine. As soon as you smell the chlorine from a tap, turn it off and move to the next one. If you cannot smell chlorine at an outlet, repeat steps 1–3, adding additional chlorine bleach, until you can smell chlorine at all outlets.

5. Let the water stand in the pipes 8 to 12 hours. *Do not use any during that time.*

6. After 8 to 12 hours, run water through all outlets until there is no more chlorine odor.

Warning: Heavily chlorinated water may kill grass or shrubbery.

To thoroughly disinfect wells completed in fractured rock, it may be necessary to back flush the well with chlorinated water (100–500 p.p.m. chlorine) to disinfect the cracks and crevices connected to the well.

For reconstructed wells or contaminated wells, the chlorine residual at the end of the disinfection period should be measured.

Well Yield

Factors that determine well yield include the type of well, the character of the aquifer, and the depth of penetration into the aquifer.

Well yield should be determined before you buy a pump. Pump capacity should not exceed the yield.

ABANDONING A WELL

Wells are sometimes abandoned because of low yield or poor quality water.

Do not let an abandoned well become a hazard to humans or animals or a receptacle for waste. An old contaminated well can contaminate your new well or your neighbors' wells.

Check with your county health officer. There may be State regulations regarding the abandonment of wells.

The well should be filled in such a way as to prevent possible contamination of the ground water and provide stable conditions at the surface. In many cases, some concrete fill will be necessary to insure permanence.

Before filling a dug well, remove as much of the upper curbing as possible. Old curbing may become porous and allow contaminated water to enter the aquifer.

Plug artesian wells at the impervious layer above the aquifer to prevent water from escaping and being wasted.

Spring and Seeps

Springs are places where ground water flows or issues from the earth, either by gravity or by artesian pressure, in a concentrated stream.

Seeps occur where ground water comes to the surface over an area without concentration. They may be developed as a water-supply source by installing an infiltration gallery to intercept the required volume of water. An infiltration gallery consists of a system of porous, perforated, or open joint pipe or other conduit draining to a collection chamber.

Springs and seeps sometimes occur in areas subject to frequent flooding. Some springs drain sink holes and are very subject to contamination. Before developing a spring as a water-supply source, request the local health officer to make a sanitary survey of the area to determine the suitability of the spring and the required surface protection.

Because springs and seeps are close to the surface, special care needs to be taken to protect them from surface pollution. The overflow should be above flood level. Surface runoff should be diverted from the area within 30 feet of the spring. Livestock should not be permitted within 60 feet of the spring. As springs are rarely located conveniently to the point of use, if possible let the water flow by gravity to a storage reservoir near the point of use.

Figure 7 and 8 illustrate desirable spring construction and protection.

SURFACE WATER SOURCES

Satisfactory ground water may be unobtainable in some areas. Use of surface water must then be considered. Possible surface water sources include ponds, lakes, streams, irrigation ditches, and cisterns.

Use of surface water sources can involve special problems. For example, if you plan to divert or dam water, you must first investigate water rights and possible restrictions. And the water should always be disinfected to make it safe to use.

Ponds

Ponds are probably the most commonly used surface water sources for a water supply. You can either use an existing pond or build one.

Use of a pond involves selection of a suitable site, making a sanitary survey of the area, determining the size of pond and catchment area needed, and other details.

If possible, the watershed area draining into a pond should be fenced to exclude livestock and grassed to prevent erosion.

Lakes, Streams, and Irrigation Ditches

Lakes, streams, and irrigation ditches often present special problems as primary or secondary water

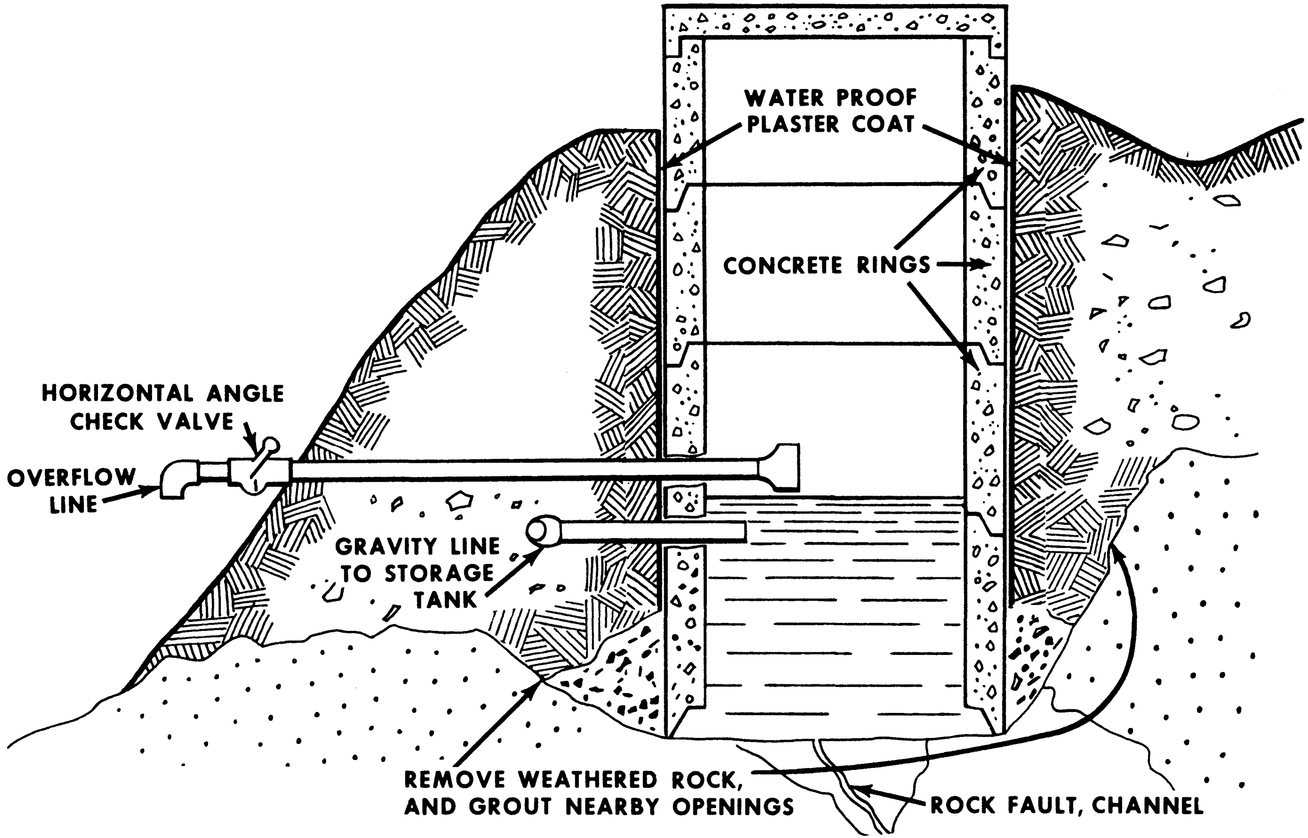

FIGURE 7.—Development of spring in rock formation. Proper protection to avoid pollution of the water is essential.

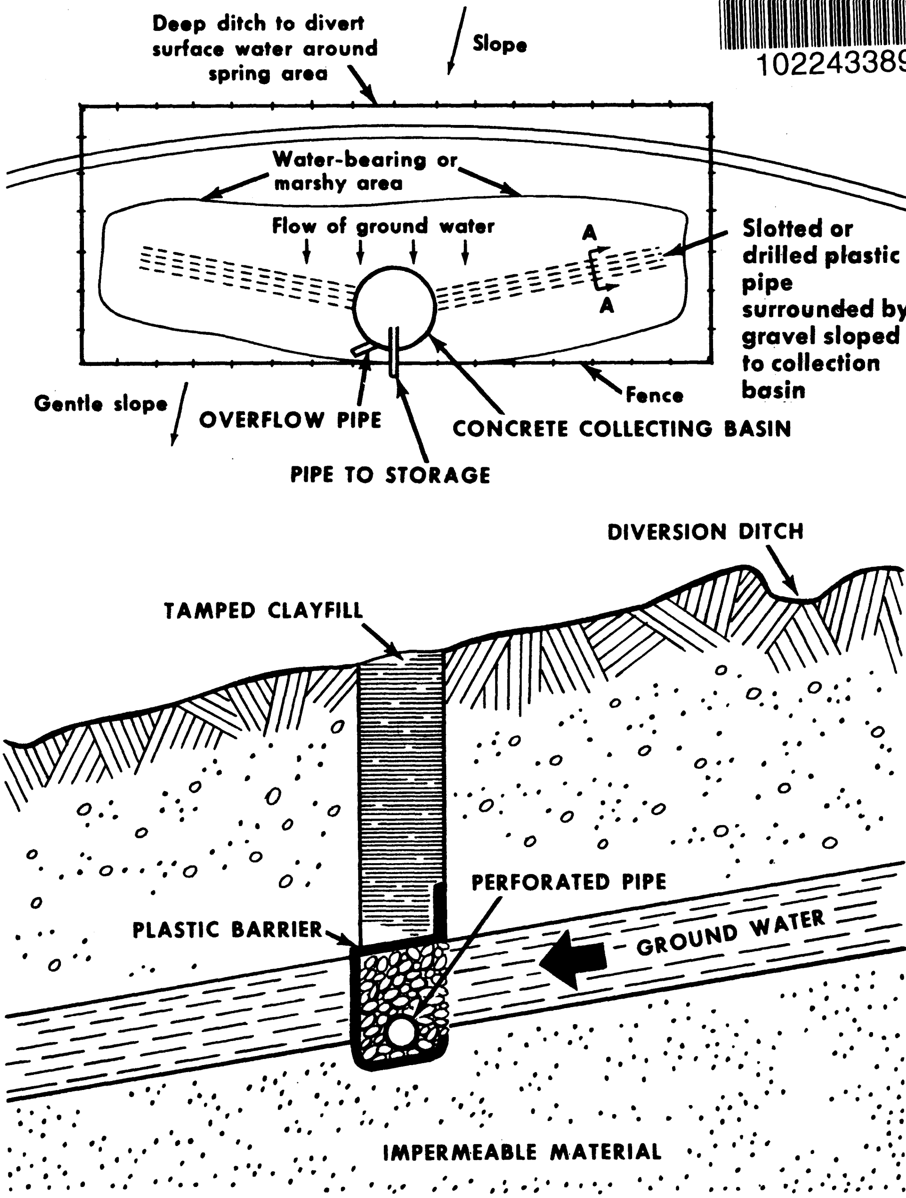

FIGURE 8.—Development of spring in water-bearing or marshy area. Bottom drawing shows profile of section A–A in top drawing. Get recommendations from Soil Conservation Service as to the size of diversion ditch to use. Perforated plastic may be used in place of terra-cotta pipe.

sources. For example, irrigation ditches often contain untreated sewage or manure.

Check with your local health officer before you even consider using such sources for a water supply.

Cisterns

Cisterns may be used to store runoff from roofs or paved catchment areas. In some areas, it may be difficult to collect and store enough rainfall to meet your total water requirements. Local rainfall records should be reviewed for both amount and frequency of expected rainfall as a basis for sizing both catchment area and cistern. One inch of rain over 1,000 square feet of area is 623 gallons. Rainfall at the rate of 1 inch per hour will yield about 10 gallons per minute per 1,000 square feet.

Rainwater is comparatively pure. If you allow the first part of a rain to wash the roof and drain to waste, the water that goes into the cistern later will be less polluted. It still should be treated, however.

You can divert the first part of a rain from the cistern with either a hand valve in the downspout or with an automatic roofwash. Wasting the water is preferred to filtering. Filters must be changed occasionally. If not changed, they increase contamination. Also the small sizes normally used with household cisterns are not well suited to handling heavy downpours of rain. For these reasons, many State health departments do not recommend the use of filters.

Good cistern design and construction are vital when collecting and storing water for domestic use. Monolithic concrete construction is recommended. Round cisterns are the most economical to build. Manhole covers should fit tightly to prevent the entrance of dirt, surface water, and insects.

Cisterns should be disinfected in accordance with Public Health Service recommendations and your local health officer's recommendations.

OTHER PUBLICATIONS

For more information about water and ground water, see U.S. Department of the Interior (Geological Survey) publications "A Primer on Water" and "A Primer on Ground Water."

Publications are also available from State universities, colleges, and health departments. One in particular is "Planning Water Systems for Farm and Home." It is available from the American Association for Agricultural Engineering and Vocational Agriculture, Coordinator's Office, Agricultural Engineering Building, Athens, Ga. 30601.

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